ALASKA FEDERAL OFFSHORE
Descriptions of Geologic Plays
1995 National Resource Assessment

U.S. Minerals Management Service

HOPE BASIN ASSESSMENT PROVINCE

(Susan A. Zerwick)

Play 1 (UAHB0101[1]). Late Sequence Play: This play includes all Oligocene(?) and younger sediments in the assessment area. Shallow shelf or fluvio-deltaic sandstones form the most likely reservoir rocks. Two exploratory wells drilled in Kotzebue basin indicate that these rocks are highly porous. Organic material in the wells is cellulosic, with hydrogen indices generally below 200 mgHC/gTOC, indicating that any hydrocarbons produced would probably be gas. Total organic carbon (TOC) values average over 1.0%, but are associated with coals and confined to the upper, thermally immature part of the sequence (Mobil E&P, 1981). Only very small volumes of this sequence, in the deepest parts of the basin, reach thermal maturity. Hydrocarbons would have to migrate into Late Sequence reservoirs from underlying, thermally mature sources in older sequences. Traps within the Late Sequence play were formed during the second, or Miocene, stage of faulting, well before the deepest sediments reached thermal maturity, probably in Pliocene or Pleistocene time.

Play 2 (UAHB0201). Early Sequence Play: This play consists mostly of Eocene(?) rocks. The Kotzebue basin wells penetrated rocks of Eocene age that are highly volcaniclastic and therefore subject to diagenetic processes of porosity destruction. Coupled with greater burial depth, this causes the reservoir potential of the Early Sequence play to be considerably lower than that of the Late Sequence play. We speculate that reservoirs consist primarily of fluvio-deltaic sands and conglomerates deposited along the edges of rift grabens. Organic matter is cellulosic, hydrogen indices are generally below 200 mgHC/gTOC, and TOC values average <0.5% in the Kotzebue basin wells (Mobil E&P, 1981). The source potential of these rocks is therefore very poor. The Early Sequence reaches thermal maturity in the central areas of both Hope basin and Kotzebue basin beneath Kotzebue Sound. Most of the Early Sequence sediments reached thermal maturity late in the deposition of the overlying Late Sequence (Oligocene and later). By that time faulting would already have formed abundant traps for migrating petroleum.

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[1]*The "UA" Code is the "Unique Assessment Identifier" for each play, and is the principal guide to GRASP data files.*

Plays 3 (UAHB0301 - Shallow Basal Sand Play) and 4 (UAHB0401 - Deep Basal Sand Play): The Basal Sand plays were defined to acknowledge the possible existence of sands (inferred by analogy to Norton basin) creating potential trap volumes at the base of basin fill. The two plays are separated at a burial depth of 10,000 feet, because density log porosities in the Kotzebue basin wells are predicted to fall below 10% at this depth when extrapolated using the Norton basin porosity decline rate. The preservation of a viable reservoir is therefore less likely in the deeper play. Potential source rocks would include the limited gas-prone organic material sampled in Early Sequence rocks in the two Kotzebue basin wells. Other petroleum sources of a speculative nature might include older, unsampled rocks in the deeper parts of Hope basin, or basement rocks. The Shallow Basal Sand play, by definition shallower than 10,000 feet, lies laterally apart from the zone of thermally mature strata. Lateral migration, unlikely because of the abundant faulting and apparent lack of a regional seal, would therefore be required to charge prospects in this play. The Deep Basal Sand play lies entirely within the thermally mature area, and is best positioned to be charged with hydrocarbons expelled from thermally mature source rocks.

OIL AND GAS ENDOWMENTS OF HOPE BASIN PLAYS

Risked, Undiscovered, Conventionally Recoverable Oil and Gas

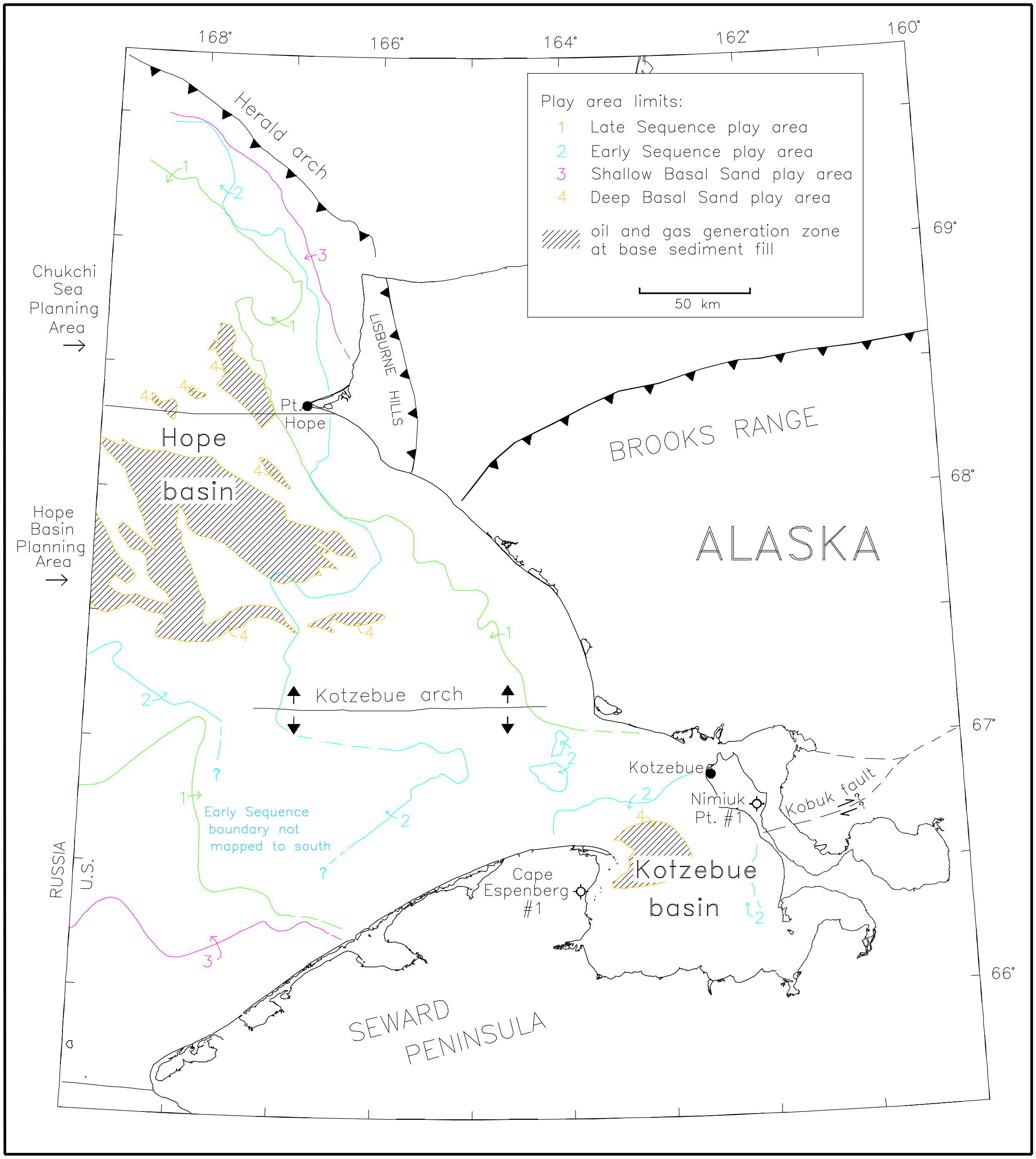
PLAY NO.	PLAY NAME (UAI * CODE)	OIL (BBO)			GAS (TCFG)		
		F95	MEAN	F05	F95	MEAN	F05
1.	Late Sequence (UAHB0101)	0.000	0.090	0.262	0.000	3.341	9.368
2.	Early Sequence (UAHB0201)	0.000	0.011	0.039	0.000	0.387	1.331
3.	Shallow Basal Sands (UAHB0301)	0.000	0.009	0.037	0.000	0.333	1.387
4.	Deep Basal Sands (UAHB0401)	0.000	0.00009	0.0006	0.000	0.004	0.026
	FASPAG AGGREGATION	***0.000***	***0.110***	***0.343***	***0.000***	***4.064***	***12.673***

* *Unique Assessment Identifier, code unique to play.*

REFERENCES CITED

Mobil E&P (Exploration and Producing Services). 1981. Visual Kerogen, Thermal Maturation, TOC and Rock-Eval Analyses, SOCAL Cape Espenberg #1 and Nimiuk Point #1 Wells, Kotzebue, Alaska. *In:* Geochemical Reports Prepared by Mobil for the Alaska Oil and Gas Conservation Commission, Dept of Nat Resources, Division of Geol and Geoph Surveys, Eagle River, Alaska, Report No 15, 44 pp.

HOPE BASIN - MAP FOR PLAYS 1 TO 4



EXPLANATION OF DATA TABLES FOR HOPE BASIN ASSESSMENT PROVINCE

RESULTS

LOG-N PARAMS (PORE)	Key mathematic parameters that describe log-normal probability distributions for volume of hydrocarbon-bearing rock, in acre-feet, for each play as reported in the **PORE** module of **GRASP**.
mu	Natural logarithm of F50 value of log-normal distribution for volume of hydrocarbon-bearing rock, or "μ", for the subject play. **mu** = ln F50. [Note: distribution **mean** = $e^{(mu + 0.5[sig. sq.])}$.]
sig. sq.	The variance of the log-normal distribution for volume of hydrocarbon-bearing rock, or "σ^2", for the subject play. **sig. sq.** = $\{\ln [0.5((F50/F16)+(F84/F50))]\}^2$.
N (MPRO)	Number of hydrocarbon pools calculated for the plays by the **MPRO** module of **GRASP** from inputs for probability distributions of prospect numbers and geologic chances of success (approximately the product of play and prospect chances of success) . The maximum (**Max**) number of pools for each play was entered into the **MONTE1** module of **GRASP** to fix the number of pools aggregated to calculate play resources.
Reserves	Sums of recoverable oil and gas volumes for pools within the play, including both proven and inferred reserve categories. A "prop" entry indicates that the reserve data are proprietary.
BCF	Billions of cubic feet of gas, recoverable, at standard (surface) conditions (here fixed at a temperature of 60° Fahrenheit or 520° Rankine, and 14.73 psi atmospheric pressure).
MMB	Millions of barrels of oil, recoverable, at standard (surface) conditions.
Undiscovered Potential	Risked, undiscovered, conventionally recoverable oil and gas resources of the play, here reported at **Means** of probability distributions.

EXPLANATION OF DATA TABLES FOR HOPE BASIN ASSESSMENT PROVINCE

Mean Pool Sizes of Ranks 1 to 3	Unrisked (or conditional) mean volumes of recoverable oil and gas in the three largest pools in the play.

PLAY INPUT DATA

F100.....F00	Fractiles for values within probability distributions entered to **GRASP** for calculations of play resources. Four-point distributions (F100, F50, F02, F00) generally indicate that calculations were conducted using log-normal mathematics. Eight-point distributions generally indicate that calculations were conducted using Monte Carlo mathematics. Choice of mathematic approach was in most cases the option of the assessor.
Prospect Area	Maximum area of prospect closure, or area within spill contour, in acres. Probability distributions for prospect areas were generally based on distributions assembled independently for each play from large numbers of prospects mapped with seismic reflection data.
Trap Fill	Trap fill fraction, or fraction of prospect area in which the reservoir is predicted to be saturated by hydrocarbons.
Pool Area	Areal extent of hydrocarbon-saturated part of prospect, in acres. Calculated using **PRASS**, or **SAMPLER** module of **GRASP**, to integrate input probability distributions for prospect areas and trap fill fractions.
Pay Thickness	Thickness of hydrocarbon-productive part of reservoir within pool areas, in feet. Probability distributions for prospect areas, trap fill fractions, and pay thicknesses are integrated in the **PORE** module of **GRASP**, to calculate a probability distribution for volume of hydrocarbon-bearing rock, in feet, within the play as reported above under **LOG-N PARAMS (PORE)** .

EXPLANATION OF DATA TABLES FOR HOPE BASIN ASSESSMENT PROVINCE

Oil Yield (Recov. B/Acre-Feet)	Oil, in barrels at standard (surface) conditions, recoverable from a volume of one acre-foot of oil-saturated reservoir in the subsurface. Oil yield probability distributions were generally calculated in a separate exercise using **PRASS** to integrate input probability distributions for porosities, oil saturations, oil shrinkage factors (or "Formation Volume Factors"), and oil recovery efficiencies.
Gas Yield (MMCF/Ac.-Ft.)	Gas, in millions of cubic feet at standard (surface) conditions, recoverable from a volume of one acre-foot of gas-saturated reservoir in the subsurface. Distributions were generally calculated in a separate exercise using **PRASS** to integrate input probability distributions for porosities, gas saturations, reservoir pressures, reservoir temperatures (in degrees Rankine), gas deviation ("Z") factors, combustible fractions (that exclude noncombustibles such as carbon dioxide, nitrogen, etc.), and gas recovery efficiencies.
Solution Gas-Oil Ratio (CF/B)	Quantity of gas dissolved in oil in the reservoir that separates from the oil when brought to standard (surface) conditions, in cubic feet recovered per barrel of produced oil.
Gas Cond. (B/MMCF)	Quantity of liquids or condensate dissolved in gas in the reservoir that separates from the gas when brought to standard (surface) conditions, in barrels recovered per million cubic feet of produced gas.
Number of Prospects.......	Probability distributions for numbers of prospects in plays, generally ranging from minimum values (F99) representing the numbers of mapped prospects, to maximum values (F00) that include speculative estimates for the numbers of additional prospects that remain unidentified (generally stratigraphic prospects, geophysically indefinite prospects, or prospects expected in areas with no seismic coverage).

EXPLANATION OF DATA TABLES FOR HOPE BASIN ASSESSMENT PROVINCE

Probabilities for Oil, Gas, or Mixed Pools

Oil (OPROB) Fraction of hydrocarbon pools that consist entirely of oil, with no free gas present. Typically, an undersaturated oil pool.

Gas (GPROB) Fraction of hydrocarbon pools consisting entirely of gas, with no free oil present.

Mixed (MXPROB) Fraction of hydrocarbon pools that contain both oil and gas as free phases, the gas usually present as a gas cap overlying the oil.

Fraction of Net Pay to Oil (OFRAC) When a hydrocarbon pool is modeled as a mixed case, with both oil and gas present, the fraction of pool volume that is saturated by oil in the subsurface.

Play Chance Success Probability that the play contains at least one pool of technically-recoverable hydrocarbons (that would flow into a conventional wellbore in a flow test or during production).

Prospect Chance Success The fraction of prospects within the play that are predicted to contain hydrocarbon pools, given the condition that at least one pool of technically-recoverable hydrocarbons occurs within the play.

Play Type (E-F-C)

Play classification scheme.

E — **Established** play, in which significant numbers of fields have been discovered, providing the assessor with data for pool size distributions and reservoirs sufficient to allow the assessor to model the play with confidence.

F — **Frontier** play, where exploration activities are at an early stage. Some wells have already been drilled to test the play concept but no commercial fields have been established.

EXPLANATION OF DATA TABLES FOR HOPE BASIN ASSESSMENT PROVINCE

C	**Conceptual** play, hypothesized by analysts based on the subsurface geologic knowledge of the area. Such plays remain hypothetical and the play concept has not been tested.

HOPE BASIN

Play				Log-N Params. PORE		N (MPRO)		Reserves		Undiscovered Potentia	
				Ac/Ft	Ac/Ft	No. Pools		Gas	Oil	Gas	Oil
No.	Area	UAI Code	Name	mu	sig. sq.	Mean	Max	(BCF)	(MMB)	(BCF)	(MMB)
1	Hope	UAHB0101	Late Sequence Play	12.843	1.1839	8.7	40	0	0	3341	90
2	Hope	UAHB0201	Early Sequence Play	12.100	1.0140	5.4	34	0	0	387	11
3	Hope	UAHB0301	Shallow Basal Sands Play	11.628	0.9317	5.9	48	0	0	333	9
4	Hope	UAHB0401	Deep Basal Sands Play	11.619	0.8951	0.2	6	0	0	4	0.1

PLAY		MEAN POOL SIZES OF RANKS 1 TO 3						INPUT DATA					
		Pool #1		Pool #2		Pool #3		Prospect Area (Acres)					
		Gas	Oil	Gas	Oil	Gas	Oil						
No.	Name	(BCF)	(MMB)	(BCF)	(MMB)	(BCF)	(MMB)	F100	F95	F75	F50	F25	F05
1	Late Sequence Play	1784	46	979	26	704	18	330	2600	6000	10000	19000	45000
2	Early Sequence Play	272	7	152	4	110	3	300	2500	5500	10000	19000	45000
3	Shallow Basal Sands Play	235	6	140	4	106	3	470	3300	7000	12000	21000	47000
4	Deep Basal Sands Play	30	1	15	0	10	0	470	3300	7000	12000	21000	47000

PLAY		INPUT DATA											
		Prospect Area (Acres)			Trap Fill (Dec. Frac.)								
No.	Name	F02	F01	F00	F100	F95	F75	F50	F25	F05	F02	F01	F00
1	Late Sequence Play		79000	150000	0.05	0.10	0.13	0.15	0.19	0.25		0.30	0.45
2	Early Sequence Play		83000	170000	0.05	0.10	0.13	0.15	0.19	0.25		0.30	0.45
3	Shallow Basal Sands Play		80000	150000	0.05	0.10	0.13	0.15	0.19	0.25		0.30	0.45
4	Deep Basal Sands Play		80000	150000	0.05	0.10	0.13	0.15	0.19	0.25		0.30	0.45

HOPE BASIN

PLAY		INPUT DATA													
PLAY		Pool Area (Acres)									Pay Thickness (Feet)				
No.	Name	F100	F95	F75	F50	F25	F05	F02	F01	F00	F100	F95	F75	F50	F25
1	Late Sequence Play	41			1609			12139		62489	42			235	
2	Early Sequence Play	47			1636			11666		57370	34			110	
3	Shallow Basal Sands Play	63			1869			12158		55499	18			60	
4	Deep Basal Sands Play	67			1854			11568		51050	18			60	

PLAY		INPUT DATA															
PLAY		Pay Thickness (Feet)				Oil Yield (Recov. B/Acre-Foot)								Gas Yield (MMCF/Ac.-Ft)			
No.	Name	F05	F02	F01	F00	F100	F95	F75	F50	F25	F05	F01	F00	F100	F95	F75	F50
1	Late Sequence Play		610		1322	20	71	127	192	289	520	786	1830	0.058	0.182	0.310	0.449
2	Early Sequence Play		210		355	31	68	97	125	161	231	298	500	0.023	0.075	0.129	0.189
3	Shallow Basal Sands Play		115		195	11	40	71	107	160	286	431	993	0.018	0.074	0.142	0.223
4	Deep Basal Sands Play		115		195	4	10	16	21	29	46	63	122	0.026	0.064	0.098	0.131

PLAY		INPUT DATA															
PLAY		Gas Yield (MMCF/Ac.-Ft)				Solution Gas Oil Ratio (CF/B)								Gas Cond. (B/MMCF)			
No.	Name	F25	F05	F01	F00	F100	F95	F75	F50	F25	F05	F01	F00	F100	F95	F75	F50
1	Late Sequence Play	0.651	1.110	1.614	3.471	37	105	170	235	330	570	740	1400	6	13	19	24
2	Early Sequence Play	0.276	0.477	0.700	1.535	44	122	202	285	405	670	949	1920	6	13	19	24
3	Shallow Basal Sands Play	0.350	0.671	1.061	2.701	83	192	285	369	485	720	949	1670	6	13	19	24
4	Deep Basal Sands Play	0.176	0.269	0.363	0.666	970	1080	1125	1180	1220	1290	1323	1430	6	13	19	24

HOPE BASIN

PLAY		INPUT DATA											
		Gas Cond. (B/MMCF)				Number of Prospects in Play							
No.	Name	F25	F05	F01	F00	F99	F95	F75	F50	F25	F05	F01	F00
1	Late Sequence Play	31	46	60	110	60	64	71	75	80	88	95	110
2	Early Sequence Play	31	46	60	110	53	57	63	68	73	80	87	100
3	Shallow Basal Sands Play	31	46	60	110	87	95	108	120	130	150	164	200
4	Deep Basal Sands Play	31	46	60	110	8	9	10	10	11	13	14	16

PLAY		INPUT DATA						
		Probabilities for Oil, Gas, or Mixed Pools			Fraction of Net	Play	Prospect	
		Oil	Gas	Mixed	Pay to Oil	Chance	Chance	Play Type
No.	Name	(OPROB)	(GPROB)	(MXPROB)	(OFRAC)	Success	Success	E - F - C
1	Late Sequence Play	0	0.9	0.1	0.05	0.50	0.23	C
2	Early Sequence Play	0	0.9	0.1	0.05	0.40	0.20	C
3	Shallow Basal Sands Play	0	0.9	0.1	0.05	0.30	0.16	C
4	Deep Basal Sands Play	0	0.9	0.1	0.05	0.27	0.05	C

EXPLANATION OF HOPE BASIN PLAY SUMMARIES

This section consists of page-size compilations of graphics that summarize the results of ***GRASP*** modeling of the undiscovered, conventionally recoverable oil and gas endowments of each of the plays identified and assessed in the province. Each play summary features a plot for risked cumulative probability distributions for oil, gas, and BOE (gas in oil-equivalent barrels added to oil), a table of results, and a plot showing ranked sizes (oil and gas shown separately) of individual hypothetical pools. These three components of the play summaries are each described below.

Risked Cumulative Probability Distributions for Plays

Each play summary provides, at page top, cumulative probability distributions for risked, undiscovered endowments of conventionally recoverable oil, gas, and BOE. Oil and BOE quantities are shown in billions of barrels (B bbl). Gas quantities are reported in trillions of cubic feet (Tcf). Resource quantities are plotted against "Cumulative frequency greater than %." A cumulative frequency value represents the probability that the play resource endowment will exceed the quantity associated with the frequency value along one of the curves (fig. 0.1). Cumulative frequency values along the curves decrease as resource quantities increase. Accordingly, the cumulative frequencies, or "probabilities for exceedance," of small resource quantities are high, and conversely, the probabilities for exceedance of large resource quantities are low.

The cumulative probability distributions are risked and curves are truncated approximately at the output play chance. In most plays, the output play chance is equal to the input play chance for success. However, in plays with very small numbers of pools, the output play chance may be significantly **lower** than the input play chance for success.

The output play chance is derived from MPRO, a module within ***GRASP*** which uses inputs for geologic chance of success to convert probability distributions for numbers of ***prospects*** to probability distributions for numbers of ***pools***. The output play chance is obtained as a mathematic extrapolation to the probability at which the numbers of pools meets or exceeds zero. In plays with 5 or more pools at the mean, this probability usually equals the input play chance for success. In plays with less than 5 pools at the mean, the zero-pool probability (or output play chance) may be much less than the input play chance. Deviation between the output play chance and the input play chance is greatest in those plays with mean numbers of pools less than unity. Such highly risky plays contribute very little resources to overall province endowments.

Identification numbers beginning with "UA" in the graphics labels are codes unique to each of the plays in the ***GRASP*** data bases.

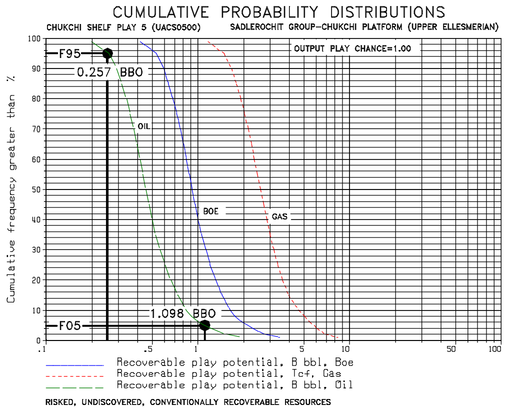
Table for Risked Play Resource Endowments

Each play summary provides, at page center, a table for risked, undiscovered play endowments of oil, gas, and BOE in billions of barrels of oil (BBO) or trillions of cubic feet of gas (TCFG). Quantities are reported at the **mean**, **F95** (a low estimate having a 95-percent frequency of exceedance), and **F05** (a high estimate having a 5-percent frequency of exceedance). Tabulated resource quantities are risked and therefore correspond to points on the cumulative probability distributions shown at page top. For plays with chances for success (play level) less than 0.95, the risked resource quantities reported at **F95** are zero.

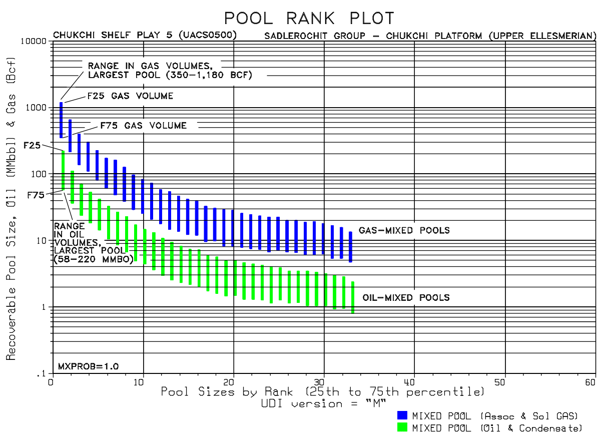
Ranked Pool Size Distributions for Plays

Each play summary provides, at page bottom, a plot showing pool sizes ranked according to size in BOE. The numbers of pools shown in the rank plots correspond to the maximum numbers of pools estimated to occur within the plays. Each pool in a pool rank plot is represented by a pair of adjoining vertical bars. The left bar of each pair represents the range (from **F75** to **F25** in the output probability distribution) of gas recoverable from the pool, and may include non-associated gas from an all-gas pool or associated gas from a gas cap and/or solution gas from oil, depending on pool type. The right bar of each pair represents the range (from **F75** to **F25**) of petroleum liquids recoverable from the same pool, and may include free oil, condensate from a gas cap, or condensate from a gas-only pool.

Volumes are shown in millions of barrels (MMbbl) of oil and billions of cubic feet (Bcf) of gas.



CHUKCHI SHELF PLAY 5 (UACS0500)			
FRACTILES	F95	MEAN	F05
GAS (TCFG)	1.478	2.993	5.823
OIL (BBO)	0.257	0.537	1.098
BOE (BBO)	0.530	1.069	2.125



The upper graph and the table report the volumes of risked, undiscovered, conventionally recoverable resources for the play. The graph, called a ***cumulative probability distribution***, shows three curves (oil, BOE, and gas) and reports the output play chance at upper right. The output play chance for Chukchi shelf play 5 is 1.0, meaning that there is a 100-percent chance that at least one hydrocarbon pool exists somewhere within the play. To illustrate how to read the graphs, dots have been placed on the ***oil*** curve at cumulative frequency values (vertical axis) of 95-percent and 5-percent. The corresponding oil quantities are 0.257 and 1.098 billions of barrels of oil. Thus, for Chukchi shelf play 5, there is a 95-percent chance that at least 0.257 billion barrels of oil are present and a 5-percent chance that more than 1.098 billion barrels are present. These same oil quantities are listed at F95 and F05 in the table.

The lower graph provides information about pool volumes and is called a ***pool rank plot***. This graph shows two sets of vertical bars, representing the quantities of oil and gas occurring ***together*** in 33 pools, the maximum number estimated to occur within this play. All pools in play 5 are modeled as mixed, that is, containing oil with a gas cap; other plays may also have all-gas or all-oil pools and show six separate commodities. Each pair of gas-oil bars in the play 5 pool rank plot shows the volume of oil in the pool and the volume of gas in the cap. The vertical bars extend across a range of possible volumes for each pool. The lower end of each bar represents the F75 resource quantity, meaning that the pool, if it exists, has a 75-percent chance of exceeding the corresponding resource quantity. Likewise, the upper end of each bar represents the F25 resource quantity. In Chukchi play 5, the largest pool offers oil volumes in the range from about 58 (F75) to 220 (F25) million barrels and gas volumes in the range from 350 (F75) to 1,180 (F25) billion cubic feet.

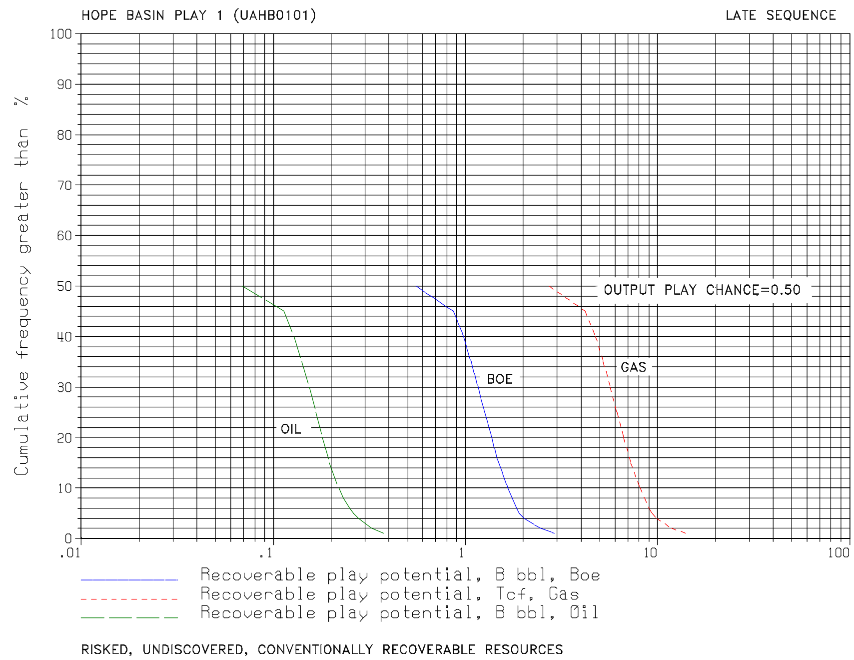
Figure 0.1: Sample play summary, Chukchi shelf play 5.

Extreme sizes outside the range between F75 and F25 volumes are not shown, but all pools offer (at low probabilities) high-side potential that may be several multiples of their median sizes (F50 or centers of vertical bars). For example, the largest pool in the pool rank plot in figure 0.1 shows F75-F25 ranges in oil volumes from 58 to 220 millions of barrels and gas volumes from 350 to 1,180 billions of cubic feet. But, these ranges do not capture the largest possible sizes of pool rank 1. This same pool has a 5-percent chance of containing over 600 million barrels of oil and 3,070 billion cubic feet of gas, or a 1-percent chance of containing over 1,140 million barrels of oil and 6,180 billion cubic feet of gas!

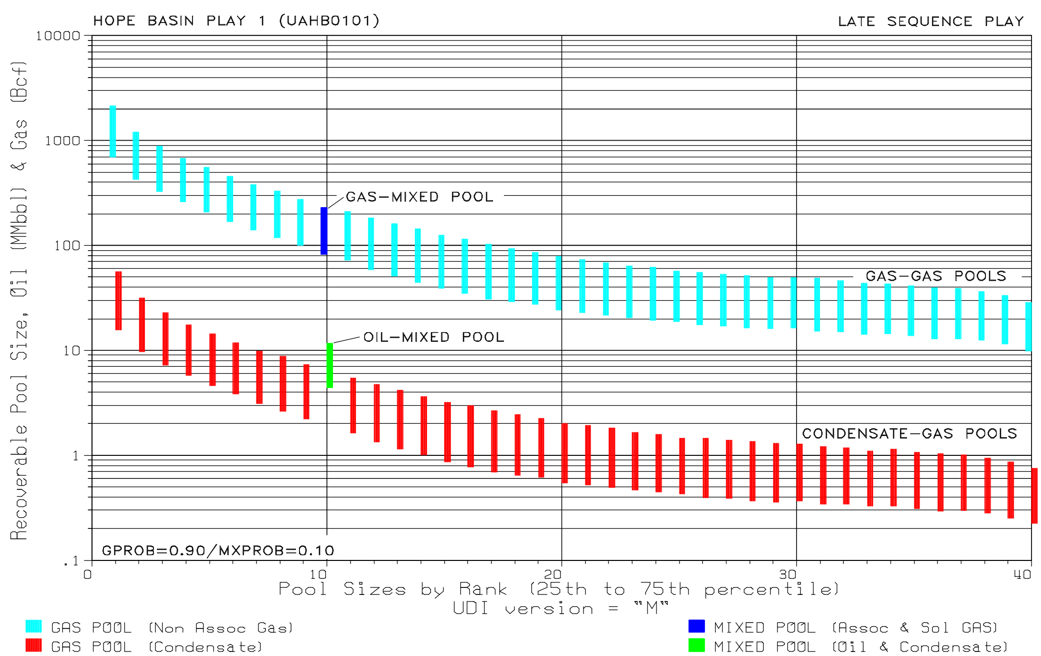
Although it might be interesting to portray the improbable yet extreme-high potential sizes of pools, choosing fractiles ranging up to F01 results in an uninformative plot where all pools nearly reach the top of the plot. For this presentation, a range based on F75-F25 values was chosen for visual clarity while still giving some impression of variance or spread.

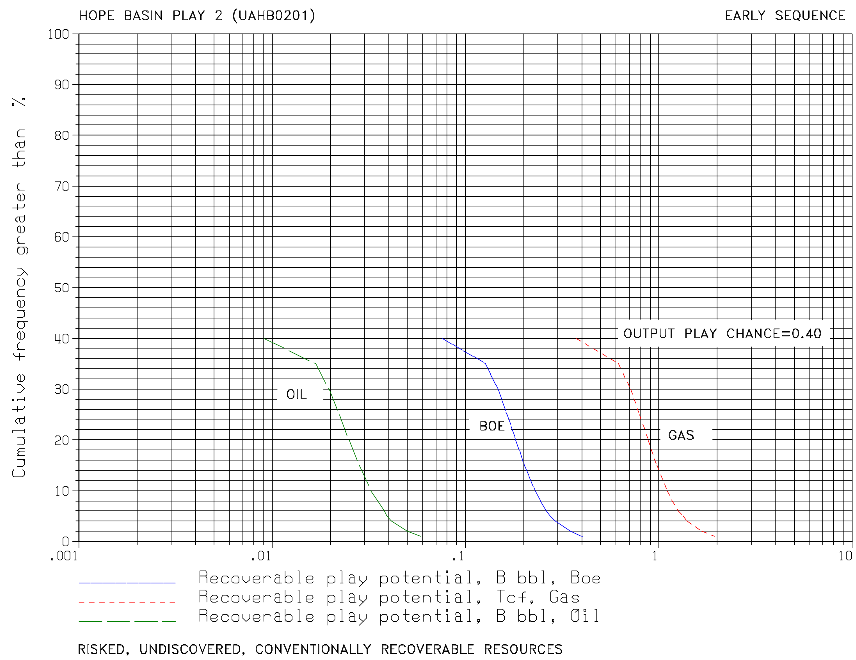
Pool volumes shown in the ranked plots are conditional upon success at the play level (i.e., a hydrocarbon pool existing ***somewhere*** within the play). The sizes of the pools posted in the rank plot have not been "risked", or multiplied against play chance of success. Therefore, except where the play chance of success equals 1.0, the sum of the mean sizes of the pools in the rank plot will exceed the risked mean play endowment that is reported in the table at page center. In fact, several of the largest pools, or even just the largest pool, may post conditional resources exceeding the risked play endowment.

Designation of pool types (oil-only, versus oil with gas cap, versus gas-only) within the play model was controlled by three data entries. Each play was assigned probabilities for (or frequencies of) occurrence of any of three pool types within the play—"OPROB" for oil-only pools, "GPROB" for gas-only pools, and "MXPROB" for mixed (oil and gas cap) pools. As the model recognizes only these three pool types, these three probability values always sum to 1.0. The three probability values control frequency of pool type sampling during ***GRASP*** runs, and, with a random number generator in ***GRASP***, ultimately dictate the sequence of pool types that appear in the play pool rank plots. The OPROB, GPROB, and/or MXPROB values that were used in the play models are posted, as appropriate, in the lower left corner of each pool rank plot.

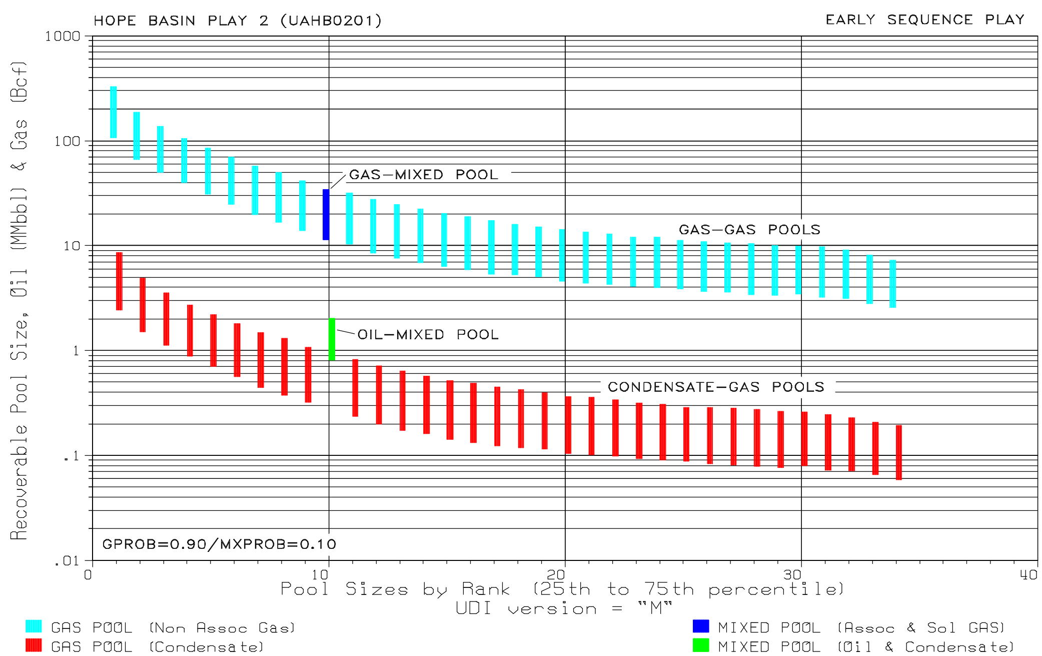


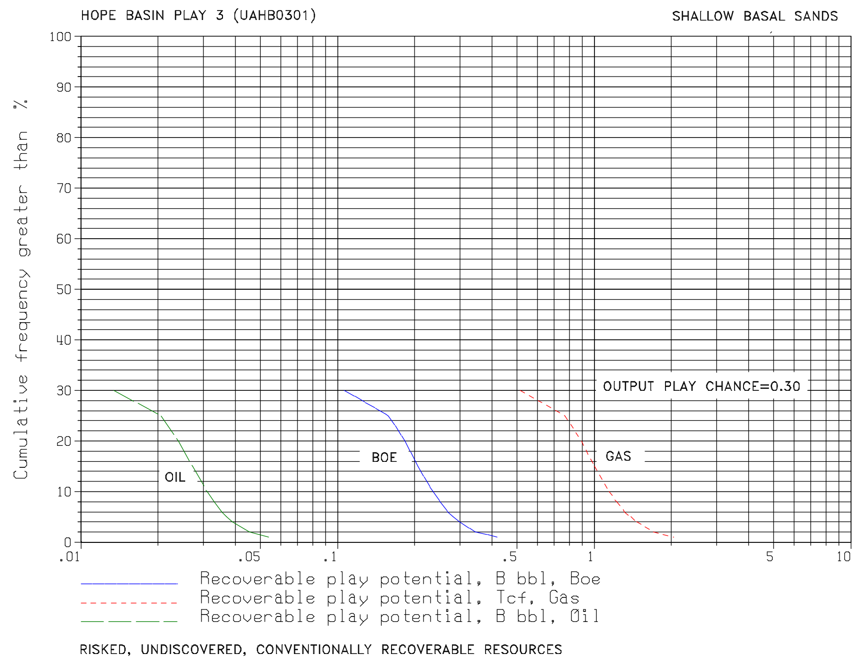
HOPE BASIN PLAY 1 (UAHB0101)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**3.341**	**9.368**
OIL (BBO)	**0.000**	**0.090**	**0.262**
BOE (BBO)	**0.000**	**0.685**	**1.912**



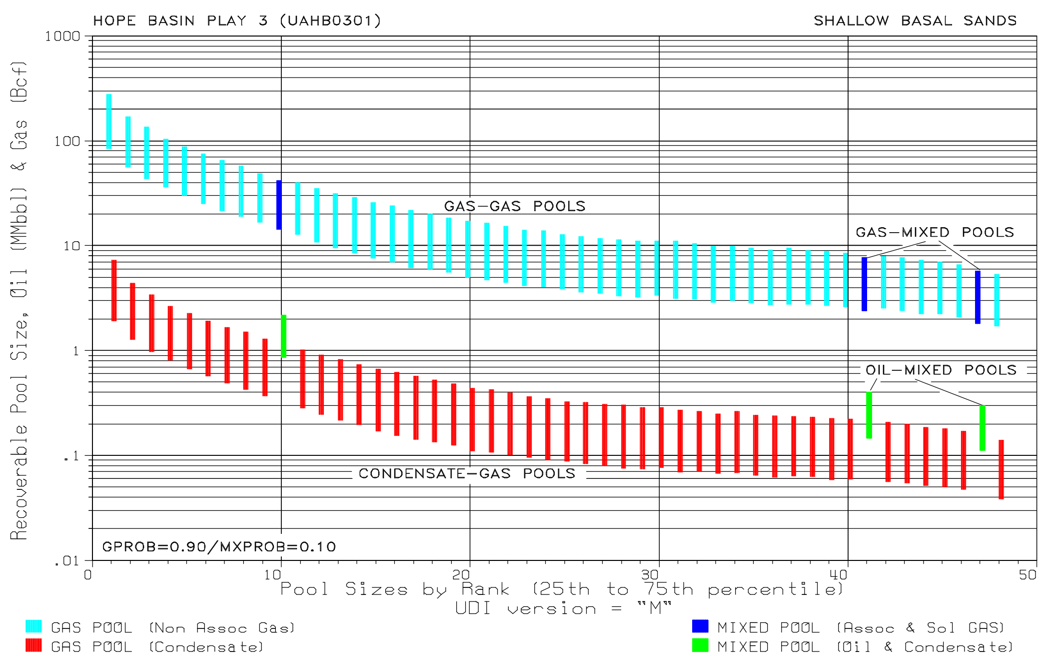


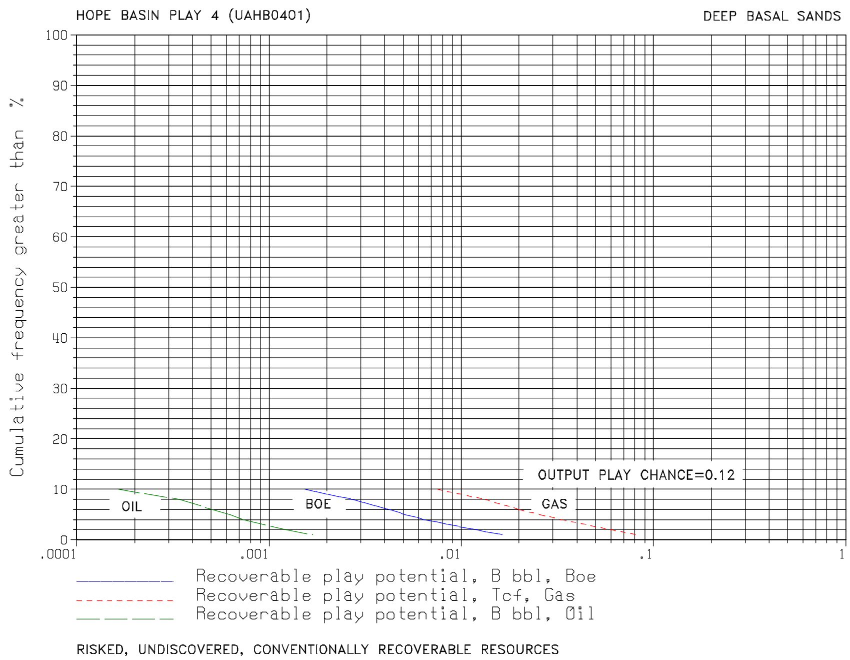
HOPE BASIN PLAY 2 (UAHB0201)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**0.387**	**1.331**
OIL (BBO)	**0.000**	**0.011**	**0.039**
BOE (BBO)	**0.000**	**0.080**	**0.273**



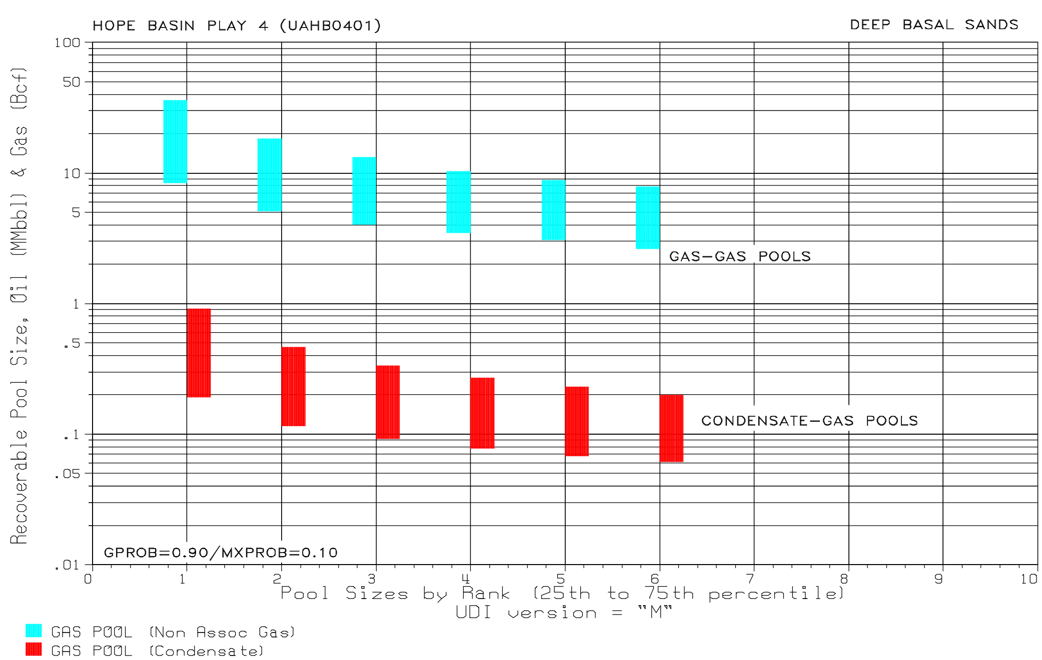


HOPE BASIN PLAY 3 (UAHB0301)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**0.333**	**1.387**
OIL (BBO)	**0.000**	**0.009**	**0.037**
BOE (BBO)	**0.000**	**0.068**	**0.282**





HOPE BASIN PLAY 4 (UAHB0401)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**0.004**	**0.026**
OIL (BBO)	**0.000**	**0.00009**	**0.0006**
BOE (BBO)	**0.000**	**0.0008**	**0.005**



ECONOMIC RESULTS, HOPE BASIN PROVINCE

(James D. Craig)

INTRODUCTION

This section summarizes the results of economic modeling using the *PRESTO-5* (*P*robabilistic *R*esource *EST*imates-*O*ffshore, version 5) computer program. The economic assessment results are influenced, to a large degree, by the undiscovered, conventionally recoverable oil and gas resources assessed using the *GRASP (G*eologic *R*esource *AS*sessment *P*rogram) computer model. The conventionally recoverable results are discussed in separate .pdf files (*Summaries of Play Results, with Cumulative Probability and Ranked Pool Plots*).

Each province summary page includes three illustrations: (1) cumulative probability plots for risked, conventionally recoverable resource distributions (oil, gas, and BOE); (2) a table comparing risked, mean, conventionally recoverable resources with the risked, mean, economically recoverable resources at current commodity prices; and (3) a price-supply graph displaying economically recoverable resource curves.

The province summary page is followed by a table reporting play-specific, economically recoverable resource estimates for two representative price scenarios: a Base Price scenario ($18/bbl-oil, $2.11/MCF-gas) representing current market conditions; and a High Price scenario ($30/bbl-oil, $3.52/MCF-gas).

PROVINCE SUMMARY PAGE

Risked Cumulative Probability Distributions

The province summary page provides, at page top, cumulative probability distributions for risked, undiscovered endowments of conventionally recoverable oil, gas, and BOE, where resource quantities are plotted against “cumulative frequency greater than %.” A cumulative frequency represents the probability that the resource endowment is equal or greater than the volume associated with that frequency value along one of the curves. For example, a 95% probability represents a 19 in 20 chance that the resource will equal, or be higher than, the volume indicated. Cumulative frequency values typically decrease as resource quantities increase. An expanded description of cumulative probability plots is given in “*Summaries of Play Results, with Cumulative Probabilities and Ranked Pool Plots* ” provided as a separate .pdf file.

Table of Risked Play Resources

The province summary page provides, at page center, a table comparing the total conventionally recoverable endowment and the smaller quantity of economically recoverable resources that could be profitably extracted under current economic and engineering conditions. Current prices are represented as $18 per barrel of oil and $2.11 per MCF of gas, where gas price is linked to oil price by energy equivalency and discount-value factors (5.62 MCF per barrel; 0.66 value discount). Conventional resource volumes correspond to points on the cumulative probability distributions (at page top). Economic resource volumes correspond to points along the mean price-supply curve (at page bottom). Resources listed as negligible (negl) have volumes lower than the significant figures shown. Not Available (N/A) means that these resources are unlikely to be produced in the foreseeable future because of reservoir conditions or the lack of a viable transportation infrastructure.

The ratio of economic to conventional resources indicates the proportion of the total undiscovered endowment that is profitable to produce under current commodity prices with proven engineering technology. However, for production to occur, commercial discoveries must be made, and the analysis does not imply discovery rates. Given the size and geologic complexity of the offshore provinces, exploration will require extensive drilling, and considering the relatively low chance of commercial success and the high cost of exploration wells, many of these frontier provinces are not likely to be thoroughly tested in the foreseeable future. The ratio of economic to conventional resources should be regarded as an opportunity indicator, rather than as a direct scaling factor for readily available hydrocarbon reserves.

Price-Supply Curves

The province summary page includes, at page bottom, a graph showing price-supply curves representing Low, Mean , and High resource production scenarios. Price-supply curves illustrate how volumes of economically recoverable resources increase as a function of commodity price. Characteristically, increases in commodity price result in corresponding increases in economically recoverable resource volumes. The economic resource volumes represent oil and gas, as yet undiscovered, that could be recovered profitably given the modeled economic and engineering parameters. At very high prices, the mean curve approaches the mean total resource endowment estimated by *GRASP*. The price-supply curves do not imply that these resources will be discovered or produced within a specific time frame, only that the opportunity exists for commercial production at levels controlled by commodity prices.

The price-supply curves were generated by the *PRESTO-5* computer program, which simulates the exploration, development, production, and transportation of pooled hydrocarbons in geologic plays within a petroleum province. Economic viability depends on the interaction of many factors defining the size and location of the hydrocarbon pools, the reservoir engineering characteristics, and economic variables relating expenditures to income from future production streams. The economic simulation is quite complex, owing to the complexities in the state of nature, and requires a sophisticated analytical model.

The following is a brief overview of the *PRESTO-5* modeling process. Geologic parameters (for example, reservoir thickness, pool area, risk) used by the *GRASP* computer model to determine conventionally recoverable resources are transferred into the *PRESTO-5* model through an interface program. Economic viability is determined by performing a discounted cash flow analysis on the expenses and modeled production stream for each pool simulated in a given trial. A Monte Carlo (random sampling) process selects engineering parameters (for example, production rate profiles, well spacing, platform installation scheduling), and cost variables (for example, platforms, wells, pipelines) from ranged distributions. Each simulation trial models the expenses, scheduling, and production for pools "discovered" within a particular play. The sampling process is repeated for productive pools in all geologic plays, and the economic resources are aggregated to the province level. The development simulation process is repeated, typically for 1000 trials, at given set of prices (oil and gas prices are linked). After the specified number of trials are completed for the first set of oil and gas prices, a new set of prices is selected and another round of simulation trials is run. This process continues for approximately 30 iterations, yielding a range of economic resource volumes tied to commodity prices. The results for all runs are given as probability distributions, where selected probability levels can be displayed as continuous price-supply curves.

These analyses determine the resource volumes that are commercially viable under a specific set of current economic and engineering assumptions. No attempt was made to upgrade engineering technology or development strategies that might be implemented in response to higher commodity prices.

The price-supply curves provided in this report are based on the most likely development scenario tailored for each particular province. All provinces were modeled on a stand-alone basis, with engineering assumptions designed for the primary hydrocarbon substance (oil or gas) identified by the *GRASP* analysis. Generally, the secondary hydrocarbon is less economically viable and places an extra burden on the primary hydrocarbon substance. For provinces without existing oil and gas infrastructure, the modeling scenarios were designed assuming that the primary substance would drive initial development in a particular province. Oil-prone provinces were modeled as "oil-only" production, with gas reinjected for reservoir pressure maintenance to maximize oil recovery. Gas-prone provinces were modeled with both gas and oil production because natural gas-liquids (or condensates) are not reinjected. Often the volume of condensates in gas-prone provinces exceeds any volume of non-associated crude oil. All hydrocarbon liquids are commingled in production and transportation systems.

This economic analysis assumes 1995 as the base year. Higher <u>nominal</u> commodity prices in the future (price increases only at the rate of inflation) do not result in higher estimated volumes of economically recoverable resources, whereas higher <u>real</u> commodity prices (increases above the rate of inflation) do increase the economically recoverable resources. The economic model assumes that commodity price and infrastructure costs were inflated equally at an assumed 3% annual inflation rate (flat real price and cost paths). The price-supply curves can be used to project economic resource volumes relative to future price if appropriate discounting back to the 1995 base year is made to account for real price and real costs changes in the intervening years.

The price-supply graph usually contains three curves, corresponding to Low, Mean, and High resource production levels. The Low resource case represents a 95% probability (19 in 20 chance) that the resources are equal to, or exceed, the volumes derived from the price-supply curves. The High resource case represents the 5% exceedance level (1 in 20 chance). The Mean resource case represents the average. In high-cost and high-risk provinces, where there are no economically recoverable resources at the 95% probability level, no "Low" curve is displayed. An apparent anomaly is observed in some cases where the lower tail of the "Mean" price-supply curve indicates economic resources greater than the "High" (5% probability) curve. This situation occurs at low prices where the probability of economic success drops below 5%, and the Mean curve is obtained from the few productive trials occurring at probabilities below 5%.

A few additional observations concerning price-supply curves are noteworthy. Following established convention for price-supply curves, these graphs are rotated from the usual mathematical display of X-Y plots. Although shown along the vertical (Y) axis, price is the independent variable and resource is the dependent variable. In many of the gas-prone basins, price-supply curves will display an abrupt step below which no risked economically recoverable resources are modeled. This step corresponds to the minimum resource value required to overcome the cost of production and transportation infrastructure. Because of the distances to Asian markets, the assumed destination for Alaska gas production, natural gas must be converted to liquid form for transportation by ships. The infrastructure associated with conversion into liquefied natural gas (or LNG) does not lend itself to incremental additions for grassroots projects; therefore, an abrupt "cost-hurdle" created by large LNG and marine terminal installations must be overcome by significant resource volumes.

Finally, the reader must be aware that these price-supply curves are models of <u>risked</u> hydrocarbon resources. Both the <u>geologic risk</u> that the resources are pooled and recoverable as well as the <u>economic risk</u> that development is profitable under the assumed economic and technologic conditions are factored into the reported results. This means that although very low resource volumes are reported as "economically recoverable", these low volumes, in fact, do not correspond to actual quantities of oil or gas. At low prices, risk is dominated by economic factors associated with engineering cost and reservoir performance variables. At high prices, risk is dominated by geologic factors related to volumetric variables. **Risked price-supply curves are most appropriately used to define the comparative potential of petroleum provinces under changing price and probability conditions.** They do not predict the timing of resource discovery or rate of conversion of undiscovered resources to future production. As previously stated, future production of the modeled economically recoverable resources will require extensive exploration programs. In the Alaska offshore, future leasing and exploration activities are likely to be driven by "high-side potential", combining perceptions of greater rewards at higher risk, higher future commodity prices, and innovative technology to reduce costs.

TABLE FOR PLAY RESOURCE DISTRIBUTIONS

The risked mean contribution for each geologic play in the province is tabulated under two hypothetical price conditions. The Base Price ($18 per barrel-oil; $2.11 per MCF-gas) represents current economic conditions. The High Price ($30 per barrel-oil; $3.52 per MCF-gas) represents a situation where <u>real price</u> has increased significantly from current levels. Other economic parameters (for example, discount rate and corporate tax rate) were equal in both scenarios, as were engineering technology and cost assumptions. The play number, name, and *UAI* (*U*nique *A*ssessment *I*dentifier code) provide a link to the data presented in other sections of this report. Hydrocarbon substances are distinguished as oil (includes crude oil and gas-condensate liquids), gas (includes non-associated, associated, and dissolved gas), and BOE (gas volume is converted to barrel of oil equivalent and added to oil volume).

HOPE BASIN MODELING RESULTS

The Hope basin province was modeled for the simultaneous production of gas and oil resources. Natural gas, as the primary hydrocarbon substance, is assumed to largely support the development activities in the province, with non-associated crude oil and natural gas liquids (condensates) recovered as bi-products. At present, there is no petroleum production or transportation infrastructure in this province, and the small export terminal serving the Red Dog mining area would probably be chosen as a site for industrial expansion to handle petroleum transportation.

The development scenario assumed that gas produced from offshore fields would be transported by an 80 mile subsea pipeline to shore-based facilities constructed near the Red Dog industrial terminal. Produced gas will be converted to liquefied natural gas (LNG) and would be shipped by marine LNG carriers to markets in Japan (Yokohama), a 3500 mile shipping route. Oil and condensate liquids would be commingled and transported by pipeline to this northern terminal, and ice-reinforced tankers would shuttle oil to a southern terminal at Valdez, Alaska where it would be added to North Slope crude oil shipped to the U.S. West Coast (Los Angeles). In the Hope basin, both crude oil and condensate are expected to be high API gravity (above 40°) and will command a premium price in the West Coast marketplace.

Under the Base Price condition ($2.11 per MCFG), the Hope basin province contains an estimated 0.12 TCFG of risked mean economically recoverable gas, which amounts to only 3% of the mean conventionally recoverable gas endowment. At the High Price condition ($3.52 per MCFG), this province contains 0.249 TCFG, amounting to 6% of the mean recoverable endowment. The High Price is more representative of the current price for LNG in Pacific Rim markets. Even at the higher price, the economic resource volume is unlikely to support the development of a grassroots project in this remote area. The high development and transportation costs are overcome at a price of approximately $5.00 per MCFG, above which significant volumes of gas resources are recoverable in both the Mean and High resource cases. For example, at $7.00 per MCFG (approximately twice the current overseas LNG price), there is a 5% chance (1 in 20) that 8.5 TCFG would be economic to produce from the Hope Basin. This optimistic scenario for both commodity price and resource availability would require a substantial real increase in gas prices as well as an aggressive exploration program to discover these resources.

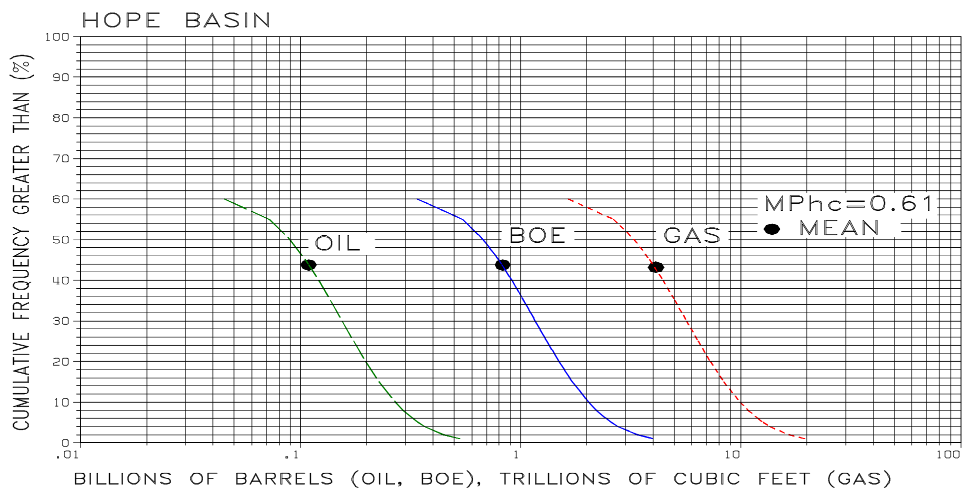
Gas resources in the Hope Basin occur in 4 geologic plays. However, one play (Late Sequence, Play 1) contains 98% of the economic gas resources under both Base and High Price conditions. This untested play is estimated to have the highest number of large undiscovered pools as well as excellent reservoir characteristics (thickness, porosity, permeability).

Gas production from the Hope Basin province is likely to hinge on co-development strategies with adjacent provinces (Chukchi, Norton) because of its relatively low resource endowment. Future exploration interest is likely to be driven by perceptions of high-side potential (which accepts higher rewards at higher risks), prompted by other gas development activities in northwestern Alaska.

Economic Results for Hope Basin assessment province. (A) Cumulative frequency distributions for **risked, undiscovered conventionally recoverable resources** ; (B) Table comparing results for conventionally and economically recoverable oil and gas; (C) Price-supply curves for **risked, economic gas** at mean and high (F05) resource cases.

BOE, total oil and gas in energy-equivalent barrels; MPhc, marginal probability for occurrence of pooled hydrocarbons in basin; BBO, billions of barrels; TCFG, trillions of cubic feet.

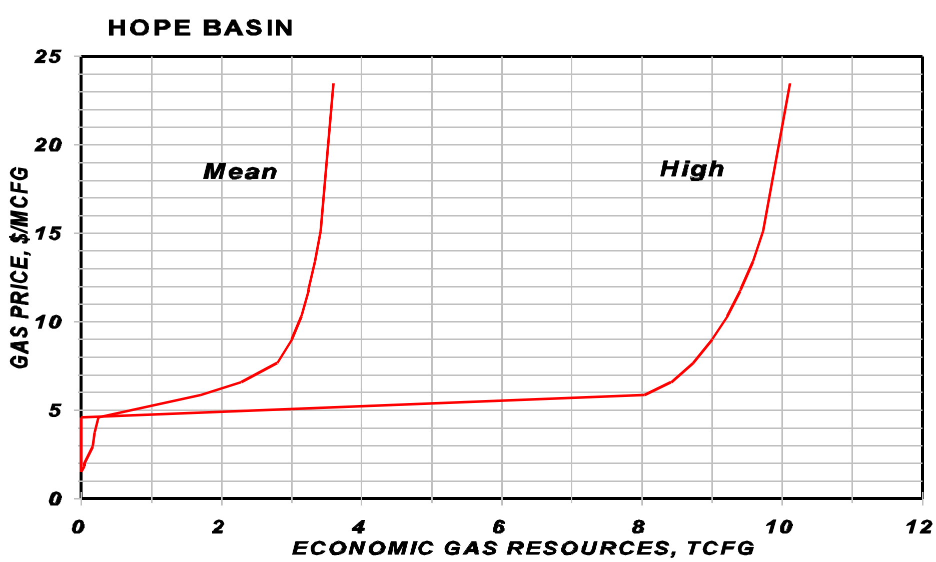
A.



B.

HOPE BASIN PROVINCE		
RESOURCE TYPE	MEAN OIL (BBO)	MEAN GAS (TCFG)
CONVENTIONALLY RECOVERABLE	0.11	4.06
ECONOMICALLY RECOVERABLE ($18)	negl	0.12
RATIO ECONOMIC/CONVENTIONAL	negl	0.03

C.



OIL AND GAS RESOURCES OF HOPE BASIN PLAYS

Risked, Undiscovered, Economically Recoverable Oil and Gas

PLAY NO.	PLAY NAME (UAI * CODE)	BASE PRICE			HIGH PRICE		
		OIL	GAS	BOE	OIL	GAS	BOE
1.	Late Sequence (UAHB0101)	0.004	0.118	0.025	0.007	0.244	0.050
2.	Early Sequence (UAHB0201)	negl	0.001	negl	negl	0.003	0.001
3.	Shallow Basal Sands (UAHB0301)	negl	0.001	negl	negl	0.002	negl
4.	Deep Basal Sands (UAHB0401)	0.000	0.000	0.000	0.000	0.000	0.000
	TOTAL	***0.004***	***0.120***	***0.025***	***0.007***	***0.249***	***0.051***

* *Unique Assessment Identifier, code unique to play.*

OIL is in billions of barrels (BBO). **GAS** is in trillion cubic feet (TCF).
BOE is barrel of oil equivalent barrels, where 5,260 cubic feet of gas = 1 equivalent barrel-oil

For direct comparisons among provinces, two prices are selected from a continuum of possible price/resource relationships illustrated on price-supply curves. **BASE PRICE** is defined as $18.00 per barrel for oil and $2.11 per thousand cubic feet for gas. **HIGH PRICE** is defined as $30.00 per barrel for oil and $3.52 per thousand cubic feet for gas. Both economic scenarios assume a 1995 base year, flat real prices and development costs, 3% inflation, 12% discount rate, 35% Federal corporate tax, and 0.66 gas price discount.

Shaded columns indicate the most likely substances to be developed in this province. Economic viability is indicated on price-supply curves which aggregate the play resources in each province.